COATINGS. ENAMELS

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HIGH-TEMPERATURE PROTECTIVE PROPERTIES OF GLASS-ENAMEL COATINGS BASED ON COAL ASH

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The compositions and properties of glass coatings intended for steel protection at hot-deformation temperatures are presented. Up to 75% coat ash, which is waste generated by thermal power plants, is introduced into the composition of glass coating. The rates of oxidation of steel 08kp under the proposed coating and in air are determined.

In developing protective glass-enamel coating applied to metals it is essential to decrease their production cost and labor consumption; therefore, finding ways to use industrial waste for this purpose is very topical. Metallurgical slag containing a substantial amount of iron oxides has low protective characteristics [1].

In our study the basis for vitreous coating was coal ash mixed with borax. Coal ash is generated in coal combustion at thermal electric plants and is an industrial waste that is hard to utilize (ash dumps around power plants). Coal ash is a finely dispersed powdered (maximum particle size ≤ 0.1 mm) aluminosilicate material that has a heterogeneous composition: it contains a crystalline and an amorphous phase.

The chemical composition of ash generated at the Reftinskaya power plant (Sverdlovsk Region) converted to a sulfate-free mixture is as follows (wt.%): 60.0 – 64.5 SiO_2, 22.0 – 27.2 Al_2O_3, 0.5 – 0.7 TiO_2, 4.5 – 8.5 Fe_2O_3, 1.7 – 4.0 CaO, 0.2 – 2.0 MgO, 0.6 – 2.0 K_2O, and 0.3 – 1.0 Na_2O.

Ash mixed with borax ($Na_2B_4O_7 \cdot 10H_2O$) forms a homogeneous glass. The composition of the resulting glass coatings is listed in Table 1.

Replacement of SiO_2 in glass by Al_2O_3 does not impair its protective properties, which makes it possible to use coal ash containing 20 – 30% Al_2O_3 as a component for producing protective coating. Melting coal ash together with borax produces an aluminoborosilicate glass. According to our data [2], low-alkali aluminoborosilicate glass of the composition $x Na_2O \cdot (43 - x) B_2O_3 \cdot 17Al_2O_3 \cdot 40SiO_2$, which is close to the compositions proposed, at $x = 8 – 20\%$ efficiently protects metal from oxidation. At a temperature of 1273 K, in 25 min 5.4 mg/cm^2 of iron from an unprotected surface of steel 0.8kp passes into scale, whereas the quantity of iron oxidized under a coating of composition 3 (Table 1) in the same time is 0.47 mg/cm^2, i.e., about one-tenth. The physicochemical properties of these glass coatings are represented in Table 2.

The TCLE and the softening point were found from the dilatometric expansion curve of samples obtained with a DKV-4 quartz dilatometer. It can be seen from the data in Ta-

TABLE 1

Composition	Mass content, %	
	coal ash	borax
1	75	25
2	65	35
3	60	40
4	50	50
5	35	65

TABLE 2

Composition	Melting point, K	Viscosity at 1323 K, dPa · sec	TCLE, 10^{-7} K^{-1}
1	853	3.4	56
2	833	2.9	60
3	823	2.8	64
4	803	2.7	69
5	753	2.6	86

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ble 2 that the softening temperature of the composition investigated is significantly lower than the temperature of thermal treatment of steel. The viscosity of the resulting melts provides for the formation of a continuous protective film on the surface of heated metal. The TCLE of such glasses is 1.5 – 2 times lower than that of steel 0.8kp ($120 \times 10^{-7}\ K^{-1}$); as a consequence, the glass disintegrates in cooling and completely crumbles off the metal surface.

The protective properties of glass coatings were evaluated comparing the rates of oxidation of steel 0.8kp under coatings and in air, which was determined by a continuous weight method as described in [3]. The oxidation rate of unprotected steel at 1323 K was 31 mg/cm^2 and under a layer of composition 5 it was 4.1 mg/cm^2, i.e., seven times lower.

Thus, the proposed glass coating based on coal ash has good protective properties at the temperature of hot treatment of metal.

REFERENCES

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